

## ***Interactive comment on “Investigating the sensitivity to resolving aerosol interactions in downscaling regional model experiments with WRFv3.8.1 over Europe” by Vasileios Pavlidis et al.***

### **Anonymous Referee #1**

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The submitted manuscript is performing sensitivity experiments following the EURO-CORDEX framework at 50km horizontal resolutions, where a series of 5-year simulations is performed with different treatments of aerosol. This is an important contribution to the regional climate community, as the approach of including aerosols in RCMs has not been well coordinated. However, before the current study can be published, the manuscript needs substantial improvements, specifically, in the understanding of the results, and also in the way the results are presented.

It is not clear for me the difference between all the experiments listed in Table 1 (and section 2.4) (especially ARI\_Mv1, ARI\_Mv1urban, ARI\_Mv1full), and this makes also

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the results a bit difficult to understand. For someone who is not using WRF, would it be possible to explain this in a more general way, how the AOD is distributed into the different types, and what is the consequence of having rural over urban (now it is only written the percentage for different types, but it is not described in detail how this works). Some more information about the vertical distribution would also be good.

The results are a bit challenging to read, as there are many acronyms, and also it is referring to many figures in the supplementary text, which probably could have been included in the main text, and maybe some figures could be removed, as there are not always so large differences on the horizontal maps (I find figure S5 very useful, would it be possible to replace some of the tables and figures with this type of figure?).

Would it make sense to first present the results where the experiment CON, ARI-T, ARI\_Mv1, ARI\_Mv1urban, ARI\_Mv1full is described, since this is focusing on the more trivial approach to include aerosol in RCMs, and it is just depending on what is having the “best” representation of the different species to represent the direct and semi-direct effect. Then a separate section can be presented, where it is shown the effect of including the aerosol-cloud interaction, which is representing the indirect effect. Then these two simulations (ACI and ARCI) can be compared with the “best” aerosol-representation from the first part (one of the CON, ARI-T, ARI\_Mv1, ARI\_Mv1urban, ARI\_Mv1full). Now it is a lot of jumping back and forth between the different simulations, and it is not so easy to follow.

After reading the manuscript, I am not so sure what is the recommendation from the study, since when there is no aerosol climatology included (as in the CON-experiment), there is a cold bias over Europe, and this cold bias is enhanced when the aerosol is included (e.g. for ARI\_T, ARI\_Mv1). The ACI and ARCI simulations are warmer than the CON, so there is a potential to remove the cold bias when aerosol-cloud-interaction is included, but is this the take-home message that RCMs should aim for having interactive aerosol schemes? However, the impact on precipitation is very small, so in the end the aerosol treatment does not have a large impact?

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If I have understood, there is no yearly change in the aerosol (only monthly or daily data), did the authors consider to include yearly varying aerosol? I guess for 5 years of simulation, the effect is not so large, but in past studies it has been shown that RCMs that don't have transient aerosol is not representing the change in the surface radiation correctly. (Bartok et al. (2017))

General comments:

Line 15-17 (p1): "statistical significant ".what is statistical significant (and what is meant by "in some cases".. please rephrase.

Line 5-6 (p2): This sentence is not so easy to understand, especially if you don't know the difference between radiative forcing and adjustment (where I assume you mean rapid adjustment). Line 20-25 (p2 models and in EURO-CORDEX regional climate models for Europe Clim. Dyn. 49 2665–83 ] Line 15 (p5): I don't quite understand how the vertical profile of the different component is distributed in each model level. Is there some weighting doing the distribution? Would it be possible to show the vertical distribution for the different experiment?

Line 21-24 (p5): The distinguishing of rural, urban and maritime component is not clear for me. What is meant that "in this work the first two component has been implemented"? is the maritime not used? And for the experiment where the different components are used (e.g. rural or urban), is this the case for the whole domain? Or can you combine this and set rural for one part, and urban for another part? Line 2-4 (p12): are you describing a specific figure, or just the results in general? Line 9-10 (p12): does this mean that the model performance is actually better when aerosol is not included in the simulations? Line 7-9 (p13): is this related to a specific figure? Line 15 (fp13) From this line, it seems as a more general summary about the results is given, so it should maybe not be under section 3.2.4 (which is about the SW). Figure2: how about including S1 with Fig 2? Moreover, if possible, how about using a color scale which is white in the middle? (not green). Line 9 (p28): I would be careful with

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using the word climate (e.g. "aerosol effect on European climate"), since only 5 years of simulation is done.

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